XX(352675.1)

Bull. nat. Hist. Mus. Lond. (Zool.) **68**(1): 27–37 Issued 27 June 2002

A redescription of *Sousa chinensis* (Osbeck, 1765) (Mammalia, Delphinidae) and designation of a neotype

L.J. PORTER
The Swire Institute of Marine Science, The University of Hong Kong, Cape d'Aguilar, Shek O, Hong Kong Special Administrative Region, China.

SYNOPSIS. The holotype of the delphinid *Sousa chinensis*, held in the collection of the Royal College of Surgeons, London, was destroyed during the Second World War. The neotype is described herein from a male specimen obtained from the waters of Hong Kong (the Hong Kong Special Administrative Region of China since 1 July 1997). This dolphin was found newly dead in May 1996 and death determined as heart failure brought about by entanglement with fishing gear. There is currently debate over divisions within the genus *Sousa* although recent reviews suggest that the five nominal species currently designated likely comprise but one. A description of the neotype's external appearance and skeletal elements is given and compared with the information that remains for the holotype and for other specimens obtained from Hong Kong waters.

INTRODUCTION

The species *Sousa chinensis* (formerly *Delphinus sinensis*) (Osbeck, 1765) was designated after observations were made of a population of delphinids within the Pearl River Estuary, Guangdong Province, Southern China, i.e. close to Hong Kong. It was over one hundred years after the species was named, however, that the first skeleton was described from an almost entire individual collected from Xiamen (formerly Amoy), Fujian Province, approximately 700km northeast of Hong Kong (Flower, 1870). This specimen and, thus, the holotype of the species was held in the collections of the Royal College of Surgeons, London, but was subsequently destroyed during the Second World War.

Osbeck's original account noted '*Snow-white Dolphins tumbled about the ship; but at a distance they seemed nothing different from the common species, except in their white colour*'. The holotype was physically mature and although the external appearance of this particular individual was not described, the typical coloration of members of the Xiamen population was noted to be '*milky white, with pinkish fins and black eyes*' (Flower, 1870). The individuals that remain in the Pearl River and Jiulong Jiang River (Xiamen) Estuaries today, are similar in external appearances (Porter, 1998).

Four other species are included in the genus *Sousa* (Table 1), although there has been debate as to where the taxonomic divisions within it, if any, actually occur (Pilleri & Gihr, 1972; Mitchell, 1975; Zhou *et al.*, 1980; Wang & Sun, 1982; Ross *et al.*, 1994). The most recent classification of the genus as comprising one species was based upon a morphological review (Ross *et al.*, 1996) and a molecular investigation of the genus concurred with this definition (Cockcroft *et al.*, 1997). Both of these publications, however, noted that the limited availability of data from parts of the species' range, particularly Asia, did not allow definitive segregation at a subspecific level and, as such, the taxonomy of the genus is not resolved.

There have been many strandings of *Sousa chinensis* in Hong Kong waters, which comprise the eastern portion of the Pearl River Estuary, since 1990 (Porter *et al.*, 1998) although the cause of death in many cases could not be determined due to either the decomposition of, or damage to, the remains. In May 1996, however, a fresh specimen identified as *S. chinensis* was retrieved and on which a full necropsy was performed. The cause of death was determined as heart failure, most likely due to entanglement with fishing gear, as deduced by the presence of fresh net abrasions on the rostrum and neck area. This specimen has been chosen for designation as the neotype of *S. chinensis* because: (a), it was obtained from the area from which the species was originally identified; (b), it was neither significantly different from the description of the extant holotype nor other individuals measured from the Hong Kong population of *S. chinensis*; (c), its death was perceived to be accidental rather than a consequence of any ailment or abnormality and (d), its remains were intact.

MATERIALS AND METHODS

A modification of the criteria described by Perrin (1975) was used to measure the skeleton obtained from Hong Kong and herein designated as the neotype. The tympanoperiotic bones were measured in accordance with Kasuya (1973). Other skeletal remains of the same species were also examined and measured to obtain a better range of values for the species in this component of its range. All measurements were made with EPI precision calipers and recorded to the nearest millimetre or, in the case of smaller bones, 0.1 mm. Each measurement was taken several times until a confident value was established. An inventory of the measurements recorded for the neotype is included as Appendix I.

The neotype and other Hong Kong specimens were aged from three teeth, selected from the upper left jaw, which were sliced to a thickness of 110μm. The sections were etched for one hour by emersion in 5% formic acid and the dentinal growth layer groups then counted under a light microscope. One pair of dark and light stained layers is equivalent to one dentinal growth layer group which is assumed to be gained annually (Kasuya, 1976).

The equivalent holotype measurements of *Sousa chinensis* (Flower, 1870) were transformed into metric units and compared with corresponding values for the neotype. The original drawings of Flower's (1870) and photographs of the neotype were also compared. The skeletal characters of both the holotype and neotype were

© The Natural History Museum, 2002

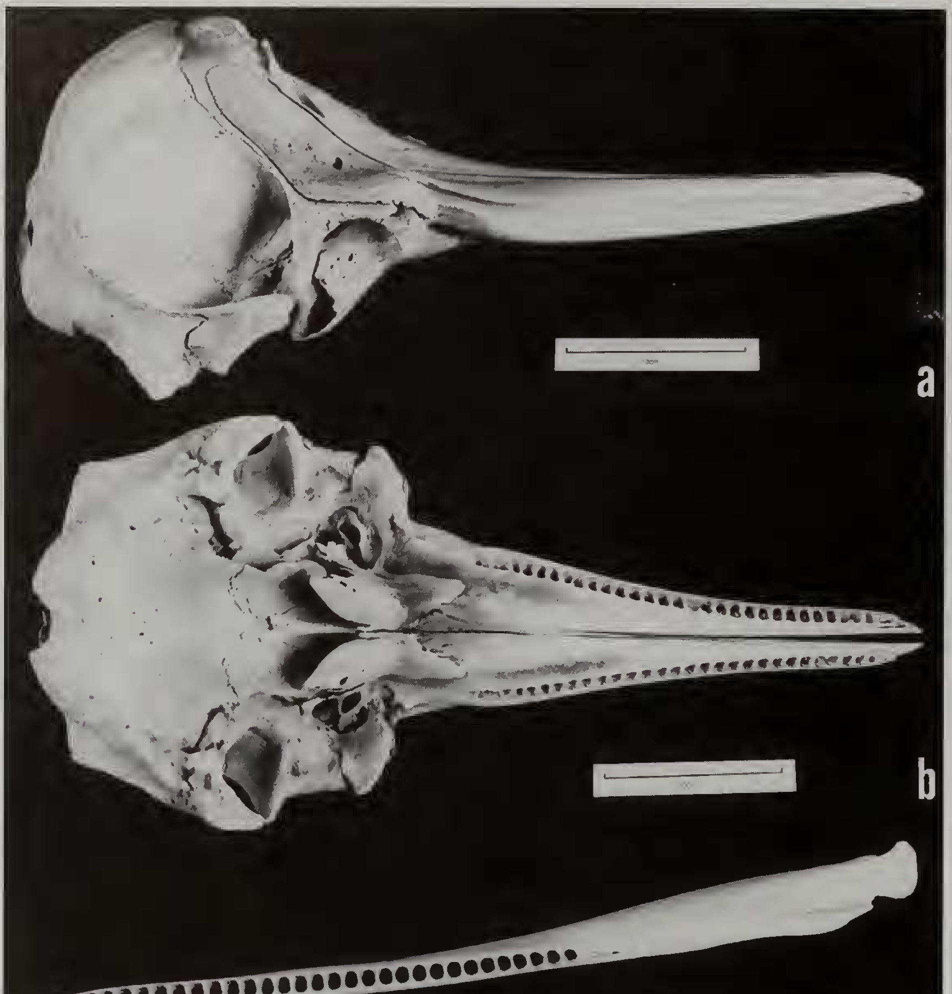


Fig. 1 The skull and jaw bones of the neotype of *Sousa chinensis* seen from a, lateral; b, ventral; c, ramus dorsal and d, dorsal aspects

Table 1 Five species classification of the genus *Sousa* according to morphological differences and geographical distribution (Ross *et al.*, 1994).

Nominal species	Geographical range
S. chinensis (Osbeck, 1765)	China to Australia
S. plumbea (Cuvier, 1829)	South Africa to India
S. lentigenosa (Owen, 1866)	India to Southeast Asia
S. teuzii (Kukenthal, 1892)	West Africa
S. borneensis (Lydekker, 1901)	Rare form in Borneo, overlapping with 'chinensis'

then compared with the range of measurements obtained from other dead adult specimens of *S. chinensis* stranded on Hong Kong beaches.

RE-DESCRIPTION OF *SOUSA CHINENSIS* (OSBECK, 1765)

Neotype: ZD 1999.360, sub-adult male, N 022° 20' 00; E 113° 55' 30, The Brothers Islands, Hong Kong's territorial waters, collected by staff of the Swire Institute of Marine Science, The University of Hong Kong. Donated to the Natural History Museum, London, under CITES permit APO/EL 3227/99.

The gently-tapering rostrum of this specimen comprised 60.7% of the total skull length and was positioned low near the base of the cranium (Fig. 1a). The upper and lower tooth rows comprised 89% and 63%, respectively, of the rostrum and ramus lengths, with 31–35

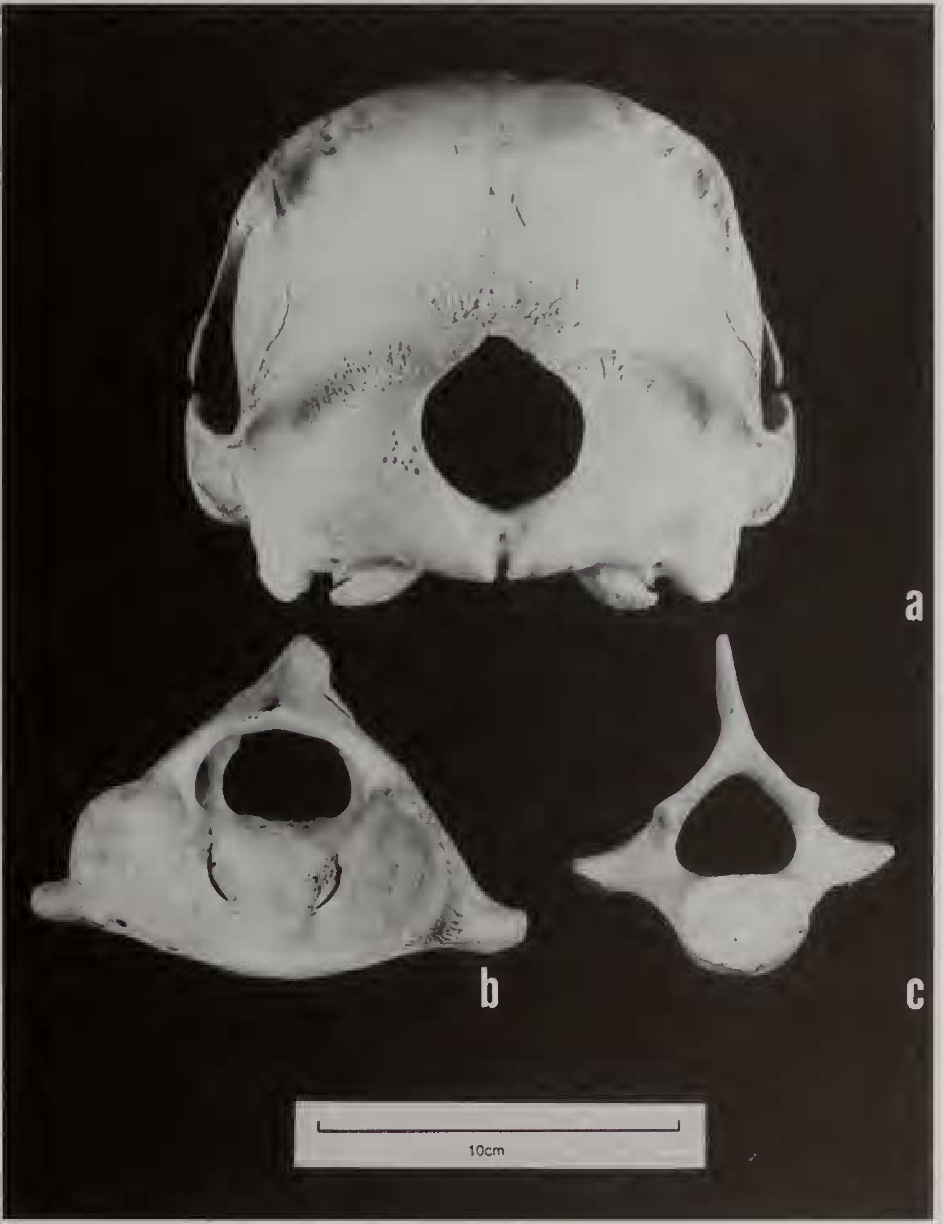


Fig. 2 The a, foramen magnum; b, atlas and c, axis of the neotype of *Sousa chinensis*

teeth in each row (Fig. 1b & c). The teeth were conical and pointed with little wear. Five dentinal layers were counted from sectioned teeth and the pulp cavity was open. The premaxillaries were in contact for almost the entirety of the rostrum length, with only a small section of the vomer exposed. Storage of the specimen in a dry environment, however, has subsequently caused the premaxillaries to gape (Fig. 1d). The premaxillaries were roughened dorsally where they met the less dense maxillaries, at the base of the nasal aperture. The posterior extremity of the rounded, right, premaxillary extended to the anterior of the nasal aperture, whereas the pointed left premaxillary was truncated at the mid-margin of the opening. The premaxillaries, therefore, encircled two thirds of the aperture, in which each nasal passage was deep-set and elliptical. The antorbital notch was not developed. The two occipital condyle margins were sharply defined and the anterior margin pointed. The channel between the condyles was long and triangular. The foramen magnum was ovoid with a slightly extended dorsal margin (Fig. 2a). Both the temporal and post-temporal fossae were ovoid with sharply-defined margins. The temporal fossae protruded where they met which, in ventral view, gave the cranium a relatively broad appearance. The orbits were rounded and the lacrimals, positioned at right angles to the orbit, were blunt with prominent dorsal ridges. The cranial articulating surface of the atlas was broad with short, transverse processes and a robust, relative to the rest of the vertebrae, neural

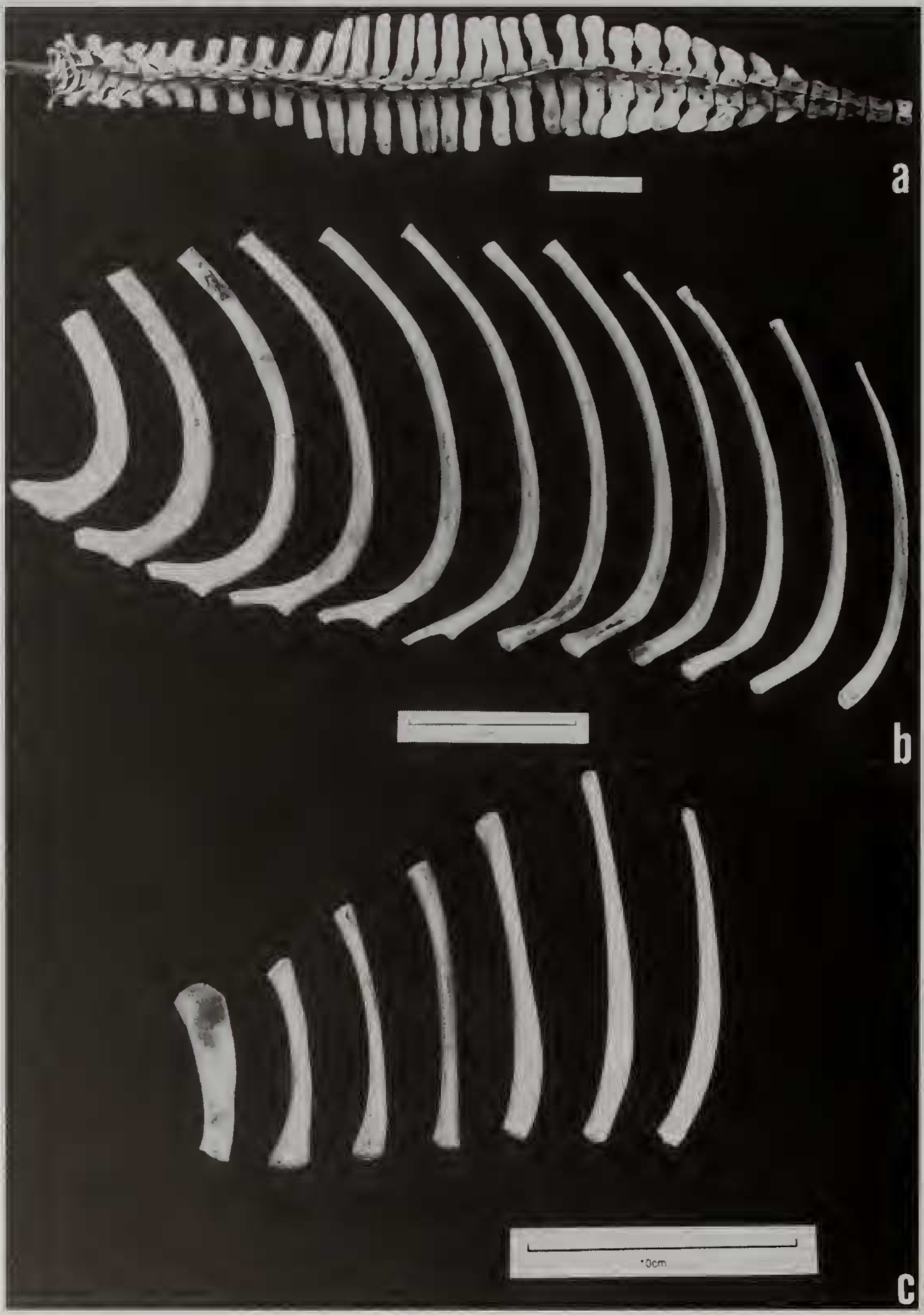


Fig. 3 The a, vertebral column; b, vertebral ribs and c, sternal and free floating ribs of the neotype of *Sousa chinensis*

spine (Fig. 2b). The axis was not fused to the atlas and had short processes but a well-developed neural spine (Fig. 2c).

There were seven cervical, 12 thoracic, 23 lumbar and 18 caudal vertebrae. No vertebrae were fused (Fig. 3a). The first vertical perforating foramen appeared on the 25th vertebra which was also the first to have greatly reduced metapophyses and the last with distinct transverse and neural processes. There were 12 vertebral ribs on both the left and right sides, six of which on each side were double-headed (Fig. 3b). There were five sternal ribs on each side (Fig. 3c).

The sternum was notched with a perforation on the left side and two lateral processes on each side (Fig. 4a; note that the right side of the sternum was damaged during preparation). There was one mesosternal element which equalled two thirds of the manubrium.

The radius and ulna were longer than the humerus, although the latter was wider and more robust. The transverse breadth of the carpals was short and the pectoral fin elongated (Fig. 4b). The scapula had a sharply pointed coracovertebral angle, a broad metacromion process and a smaller, pointed, coracoid process (Fig. 4c).

The bullae of the tympanoperiotic bones were rounded and bulbous and the dorsal plane of the periotic convex; the fundus of the internal auditory meatus and the aquaductus fallopii were ovoid; the aquaductus cochleae had a distinct ridge; the join between the cochlear portion and the rest of the periotic was rounded and smooth.

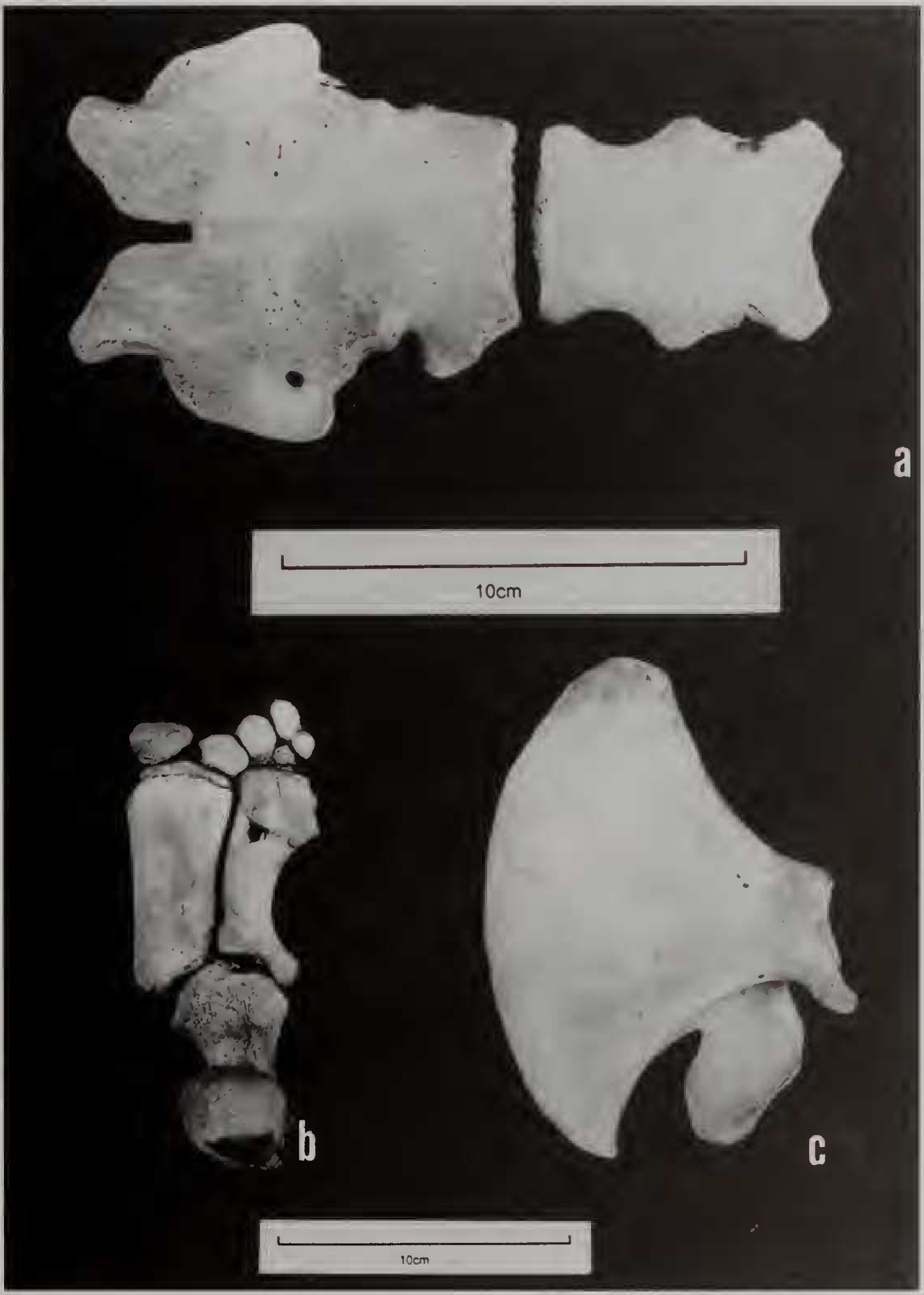
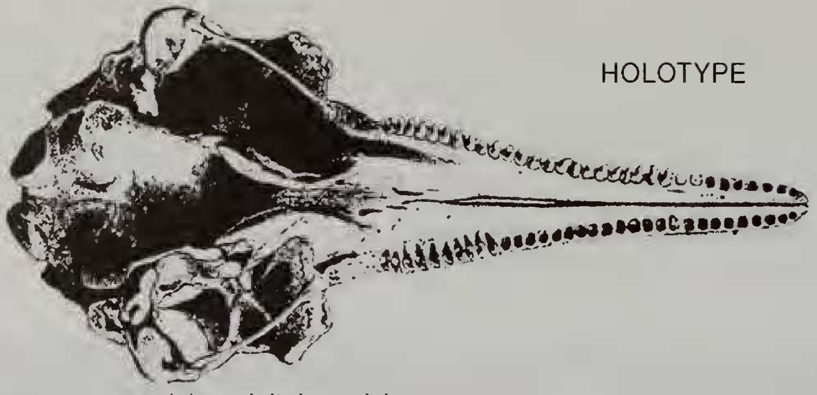
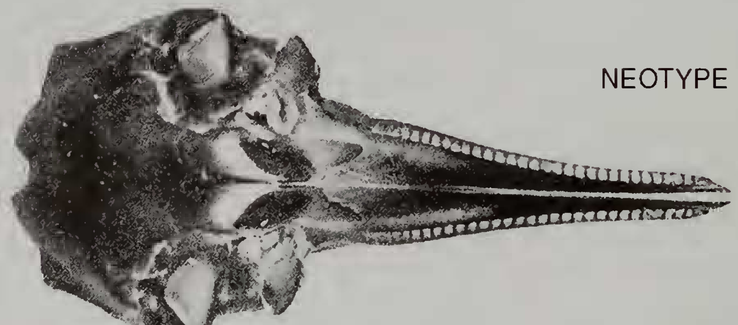


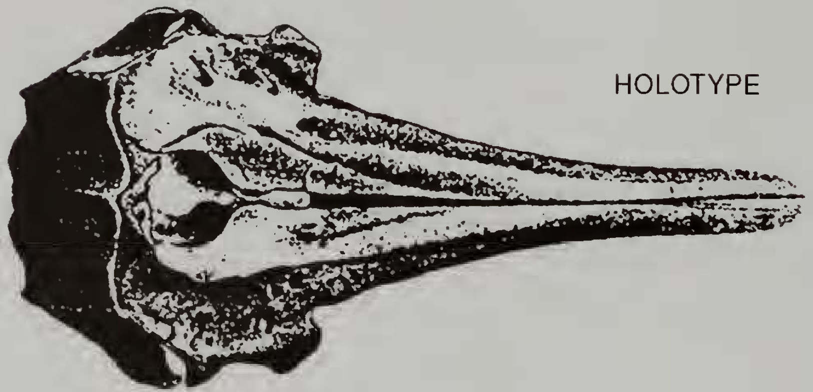
Fig. 4 The a, sternum and b, pectoral fin skeletal elements of the neotype of *Sousa chinensis*



(a) occipital condyles



(b) lacrimal flares



(c) temporal fossae

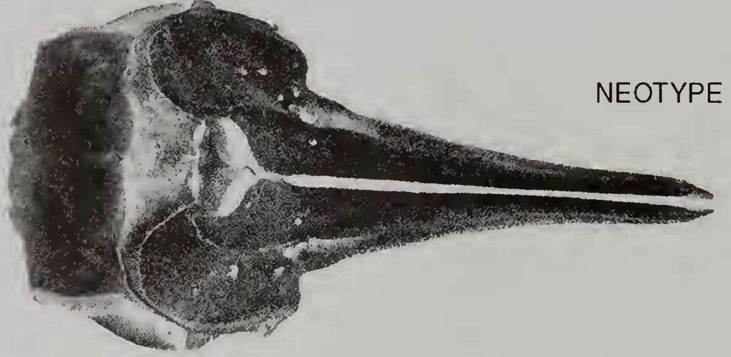


Fig. 5 A copy of the original illustrations of Flower's (1870) holotype and the corresponding views of the neotype showing differences in the a, occipital condyles; b, lacrimal flares and c, temporal fossae

COLORATION. Mainly pink with light grey around the head and darker pigmentation along the length of the back, including the leading and trailing edge of the dorsal fin and the ventral fringe of the fluke. There was dark, fragmented pigmentation on the melon, around the eyes and across the dorsal cape. Although both the dorsal and ventral surfaces of the fluke were pink, the dorsal surface of the pectoral fins were still grey and had only just begun to lighten.

EXTERNAL APPEARANCE. The body was slender but with a prominent melon. Neither the 'robustness' nor prominent peduncle, typical of other, adult individuals observed and examined from Hong Kong waters were present (Porter, 1998). The dorsal fin was slightly falcate and the flukes were small with a distinct notch. The pectoral fins were broad in the middle but tapered both distally and at the base. The 'hump-back', reportedly typical of populations west of Indonesia, has not been recorded from any individual in the South China Sea (Reeves & Leatherwood, 1994).

COMMENTS. During the post-mortem it was noted that the individual had deep scarring around the pectoral fins and torso. This healed injury was consistent with abrasion from either a rope or a similar object. It cannot be determined if this injury caused any major deformity to the pectoral fin bones although some pathology of them was observed. These injuries were distinct from those associated with the animal's death.

ETYMOLOGY. The species name is derived from its geographical location, i.e. both *sinensis* and *chinensis* referring to 'China'. The meaning of the current genus name *Sousa* has become obscure. Although the taxonomy of the genus *Sousa* has yet to be resolved, in accordance with the International Code of Zoological Nomenclature, this neotype must bear the name of the holotype.

COMPARATIVE ANALYSIS OF SPECIMENS

The age of nine Hong Kong specimens of *Sousa chinensis* used for comparative skeletal purposes in this study, ranged between 4 and 14 growth layer groups, the former number having been established as the age where rapid juvenile growth rate decreases and adult dimensions are gained (Porter, 1998). No Hong Kong specimen had reached physical maturity as determined by fusion of post-cranial elements and closure of the tooth pulp cavity. There was, therefore, no physically mature specimen to compare with the holotype. The most obvious difference, therefore, between the skeletal measurements available for the holotype and those for the neotype is that of size (Table 2). The holotype had two less lumbar vertebrae, four more caudal vertebrae and six more chevron bones than the neotype. The holotype had slightly fewer teeth than the neotype but both counts are within the range identified for other Hong Kong specimens (Table 3). A comparison of the remaining diagrams of the holotype with the neotype illustrates clearly the similarities in general shape and skull configuration. Both have large ovoid craniums with robust and elongated rostrums, the eliptical nares are deep set and the vomer is exposed (Fig. 5). Differences are apparent, however, in the occipital condyles (a) and the lacrimal flares (b), which were more prominent in the holotype. The shape of the holotype temporal fossae also differed from those of the neotype (c): in the former they were swept back towards the posterior of the skull resulting in a smaller width between them. There are differences in the degree of ossification of the scapulae, the holotype being more robust with larger coracoid and metacromion processes (Fig. 6).

The measurements obtained from the holotype, the neotype and

Table 2 *Sousa chinensis* principal skeletal dimensions and vertebral counts of the Hong Kong neotype and the holotype from Fujian Province (Flower, 1870).

	Measurement	Neotype	Holotype
1	Condylobasal length	481	526
2	Length of rostrum.	292	325
3	Width of rostrum	110.1	119
5	Width of rostrum at midlength	44.8	47
16	Greatest parietal width	140.9	163
32	Length upper tooth row to tip rostrum	260	284
33(UL)	Number of teeth (UL)	35	33
34(UR)	Number of teeth (UR)	35	32
35(LL)	Number of teeth (LL)	31	32
36(LR)	Number of teeth (LR)	32	31
37	Length of lower tooth row.	259	279
38	Greatest length of left ramus.	407	457
39	Greatest height of left ramus.	82.5	91
40a	Length of symphysis	113.3	140
48a	Number of cervical vertebrae	7	7
48	Number of thoracic vertebrae	12	12
49	Number of lumbar vertebrae	12	10
50	Number of caudal vertebrae	18	22
51	Total number of vertebrae	49	51
78	Number of vertebral ribs (left)	12	12
79	Number of vertebral ribs (right)	12	12
96	Number of chevron bones	8	14
105	Greatest length of coracoid process.	21.5	37
106	Greatest width of coracoid process.	11.6	29
107	Greatest width of metacromion process.	54.5	30
108	Greatest length of humerus.	63.9	73
109	Greatest width of humerus distally.	39.5	57
110	Greatest length of radius.	74	79
111	Greatest width of radius distally.	38.2	47
112	Greatest length of ulna.	65.9	67

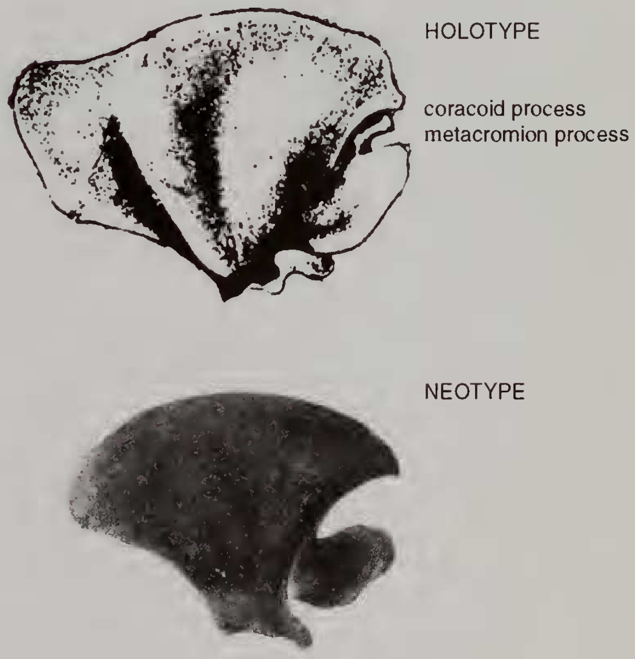


Fig. 6 A copy of the original illustrations of Flower's (1870) holotype and the corresponding views of the neotype demonstrating differences in the form of the coracoid and metacromion processes of the scapula.

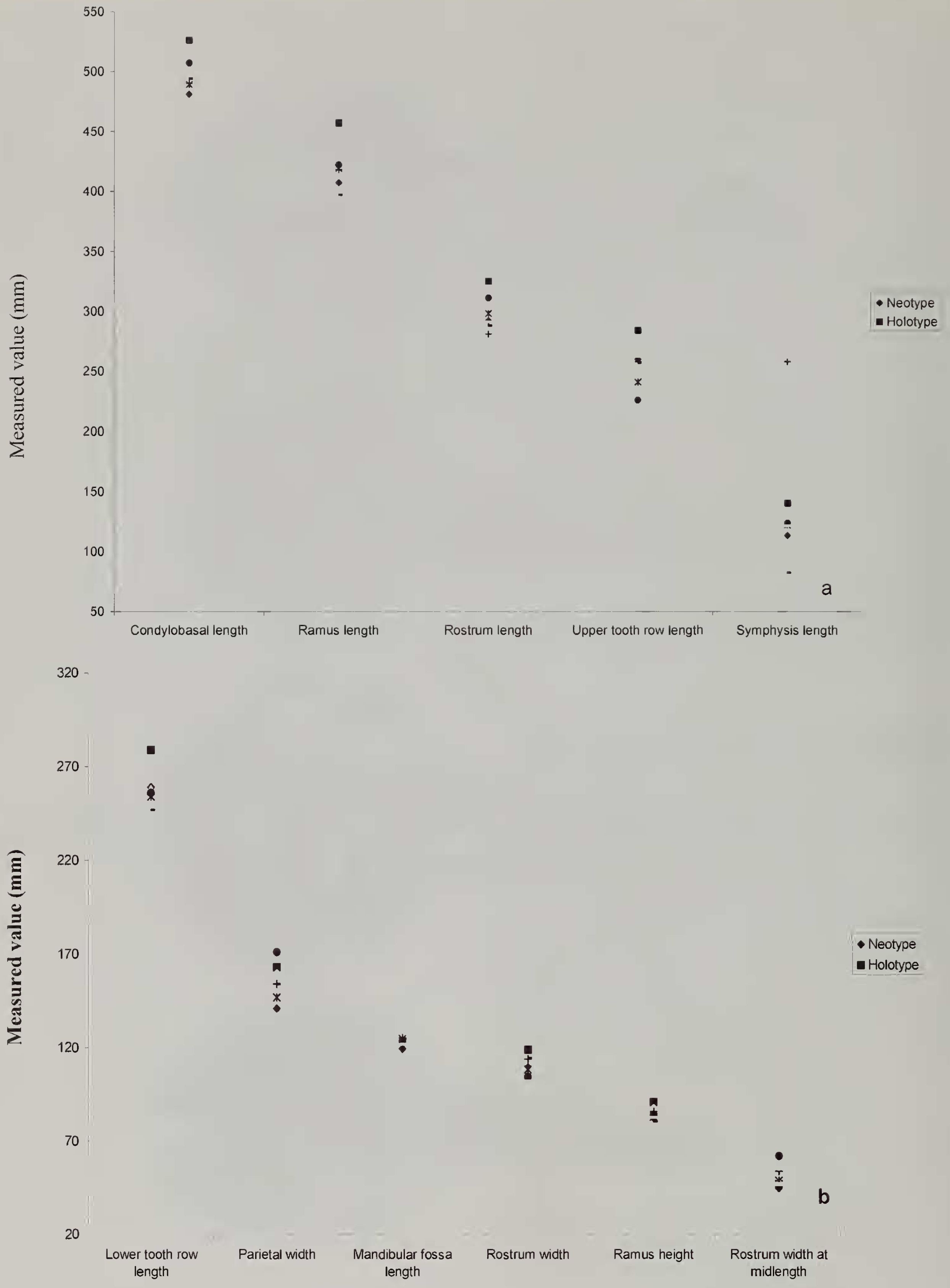


Fig. 7 Range of length and width measurements for the skulls of *Sousa chinensis* obtained from Hong Kong and the holotype demonstrating the a, greatest and b, least variation between individuals.

Table 3 The range (and average number) of teeth counted from Hong Kong *Sousa chinensis*

	Left	Right
Upper	32–36 (33.6)	32–35 (33.6)
Lower	28–34 (31.5)	27–33 (31.1)

the other eight Hong Kong specimens lie within a discrete range. The greatest variation is seen between length measurements of the skull, i.e. condylobasal (450–526 mm), rostral (257–325 mm), upper tooth row (205.5–284 mm), ramus (397–457 mm) and symphysis (82.5–258 mm). The physical maturity of the holotype is reflected in its location at the top of each of these length values (Fig. 7a). Least variation is seen between the width dimensions of the skulls, i.e., parietal (137.4–171 mm), rostral (99.2–119 mm), mid-rostral (47.8–62 mm), mandibular fossae (119.4–130.9 mm) and the lower tooth row length (247–279 mm) (Fig. 7b).

DISCUSSION

The ages of nine stranded specimens of *Sousa chinensis* examined from Hong Kong waters were determined to lie between 4 and 14 years. It is clear from the original description that the holotype was physically mature whereas no specimen obtained from Hong Kong was. This is reflected in the comparison of skeletal characters where the holotype is consistently the largest in terms of skull length measurements. The greater ossification of the scapula also is indicative of the holotype's greater age. The measurements obtained for the neotype appear to be typical for Hong Kong waters, although the sample size is currently limited. Those measurements available for the holotype are, however, within the ranges obtained for Hong Kong specimens. The difference between vertebral counts of the holotype and neotype is small and such variation in other delphinids appears typical (Perrin, 1975). It is not known if the holotype was typical of the population present in Xiamen waters at the time it was collected (1870) and, indeed, as both Hong Kong and Xiamen coastal areas have been extensively developed, any adaptive changes that both populations of *Sousa chinensis* may have undergone since the 17th century cannot be gauged. In addition, the latest review of the genus (Ross *et al.*, 1996) observes that osteological form is similar across its global range, with any slight differences being environmental rather than genetic.

The uncertainty that prevails over the taxonomy of the genus *Sousa* can only be dispelled through the continued investigation and comparison of specimens from throughout its range. As the holotype has been destroyed, the designation of a neotype is required so that such comparative studies can be conducted in relation to a defined type and, thus, the taxonomy and life history traits of the genus resolved. In addition, the herein designated neotype was obtained from the area in which the species was originally identified (Osbeck, 1765) and the same geographic region that the holotype was collected from (Flower, 1870). The meristic data of the neotype are neither significantly different from what is known of the original description of a *Sousa chinensis* skeleton (Flower 1870) nor the sample of other stranded specimens measured from Hong Kong waters. The specimen described herein, therefore, fulfils the criteria as laid out by the International Code of Zoological Nomenclature for designation as a neotype and, as such, has now been lodged in the vertebrate collection of the Natural History Museum, London (Accession No. ZD 1999.360).

ACKNOWLEDGEMENTS. The study of Hong Kong stranded marine mammals was funded by the Agriculture, Fisheries and Conservation Department (AFCD) of the Government of the Hong Kong Special Administrative Region. A special acknowledgement is made to pathologist Dr. L. Simms (AFCD) for his expertise and use of post mortem facilities. Mr. K.C. Choi and the staff of the licensing division of AFCD are gratefully acknowledged for their assistance in processing the CITES export permit. Many thanks also to Dr. G. Ross, Environment Australia, who freely gave of his expertise and greatly assisted in the taxonomic procedures and interpretations presented in this paper. The author also wishes to thank Prof. Brian Morton, Director, The Swire Institute of Marine Science, The University of Hong Kong, for his support and encouragement for this and other studies of *Sousa chinensis* conducted at the institute.

REFERENCES

Cockcroft, V.G., Leatherwood, S., Goodwin J. & Porter, L. 1997. The phylogeny of humpback dolphins genus *Sousa*: insights through mtDNA analyses. Working paper SC/49/SM25 14pp. In: Proceedings of the 49th International Whaling Commission Meeting, Scientific Committee Annual Meeting, Bournemouth, United Kingdom, 1997. International Whaling Commission, Cambridge.

Flower, W. 1870. Description of the skeleton of the Chinese white dolphin (*Delphinus sinensis* Osbeck). *Transactions of the Zoological Society of London* **7**: 151–160.

Kasuya, T. 1973. Systematic consideration of recent toothed whales based on the morphology of tympanoperiotic bone. *Scientific Report of the Whales Research Institute, Tokyo* **25**: 1–103.

—— 1976. Reconsideration of life history parameters of the spotted and striped dolphins based on cemental layers. *Scientific Report of the Whales Research Institute* **28**: 73–106.

Kukenthal, W. 1892. *Sotalia teuszii* n. sp., einplanzenfressender Delphin aus Kamerun. *Zoologischen. Jahrbuchen* **6**: 442–446.

Mitchell, E. 1975. Report of the meeting on smaller cetaceans, Montreal, April 1–11, 1974. In Review of Biology and Fisheries for Smaller Cetaceans. *Journal of the Fisheries Research Board of Canada* **24**: 2505–2513.

Osbeck, P. 1765. *Reise nach Ostindien und China*. (Translated from the original Swedish by J.G. Georgi and J.C. Koppe. Rostock. [In German]

Perrin, W.F. 1975. Variation of Spotted and Spinner porpoise (genus *Stenella*) in the Eastern Tropical Pacific and Hawaii. Bulletin of the Scripps Institute of Oceanography. University of California Press, California.

Pilleri, G, & Gihr, M. 1972. Contribution to the knowledge of the cetaceans of Pakistan with particular reference to the genera *Neomeris, Sousa, Delphinus* and *Tursiops* and description of a new Chinese porpoise (*Neomeris asiaeorientalis*). *Investions of Cetacea* **4**:107–162.

Porter, L.J. 1998. The taxonomy, ecology and conservation of Sousa chinensis (Osbeck, 1765) (Cetacea: Delphinidae) in Hong Kong waters. PhD thesis. The University of Hong Kong.

Reeves, R.R. & Leatherwood, S. 1994. *Dolphins, Porpoises and Whales: 1994–1998 Action Plan for the Conservation of Cetaceans*. IUCN/Species Survival Commission/Cetacean Specialist Group, Cambridge.

Ross, G.J.B., Heinsohn, G.E. & Cockcroft, V.G. 1994. Humpback dolphins *Sousa chinensis* (Osbeck, 1765), *Sousa plumbea* (G. Cuvier, 1829) and *Sousa teuszii* (Kukenthal, 1892). In: Handbook of Marine Mammals, Volume 5: 23–42 Ridgeway, S.H. & Harrison, R. (Eds). Academic Press, London.

Ross G.J.B., Heinsohn, G.E., Cockcroft, V.G., Parsons, E.C.M., Porter, L.J. & Preen, A. 1996. Review of the taxonomic status of the humpbacked dolphins, genus *Sousa*. Working paper UNEP/SEA95/WP19. 25pp. In: Perrin, W.F., Dolar, M.L. & Alava, M.N.R. (eds.) Report of the Workshop on the Biology and Conservation of Small Cetaceans and Dugongs of Southeast Asia, Dumaguete 1995. UNEP (W)/EAS WG.1/2. Bangkok: United Nations Environment Programme, Bangkok.

Wang, P. & Sun, J. 1982. Studies on the Zhonghua white dolphin, *Sousa chinensis*, from the South China Sea. *Transactions of the Liaoning Zoological Society* **3**: 67–74 (In Chinese).

Zhou, K, Li, Y, Qian, W. & Yang, G. 1980. Notes on three species of dolphins from the South China Sea and Jiulongjiang River. *Oceanologica et Limnologia Sinica* **11**: 306–313 [In Chinese with an English Summary].

APPENDIX 1

Skeletal measurements of the neotype.

Measurement	Neotype
Condylobasal length	481
Length of rostrum	292
Width of rostrum	110.1
Width of rostrum at 60 mm anterior	77.1
Width of rostrum at midlength	44.8
Premaxilleries width, at rostral midlength	28.9
Width of rostrum at 3/4 length, measured from posterior end	34.1
Distance from tip of rostrum to external nares	323.0
Distance from tip of rostrum to internal nares	300.0
Greatest preorbital width	185
Greatest postorbital width	208
Greatest width of external nares	50.5
Zygomatic width	203.0
Greatest width premaxilleries	82.0
Greatest parietal width	140.9
Least width between temporal fossa	137.0
Greatest length of left temporal fossa	86.6
Greatest width of temporal fossa (at right angles to length)	79.9
Major diameter of left temporal fossa	51.1
Minor diameter of left temporal fossa	45.6
Length of orbit	48.6
Length of antero-lateral face of lacrimal measured to exclude the flare on the rim	29.3
Greatest width internal nares	60.5
Greatest length pterygoid	10.30
Length upper tooth row to tip rostrum	260.0
Number of teeth – upper left	35
Number of teeth – upper right	35
Number of teeth – lower left	31
Number of teeth – lower right	32
Length of lower tooth row to tip mandible	259.0
Greatest length of left ramus	407.0
Greatest height of left ramus	82.5
Length of left mandibular fossa	119.4
Length of symphysis	113.3
Greatest width of left thyrohyal proximally	18.4
Greatest length of left thyrohyal	66.2
Greatest width of left stylohyal	13.4
Greatest length of left stylohyal	79.4
Number of thoracic vertebrae, defined as equal to number of ribs on side with greatest number	12
Number of lumbar vertebrae	12
Number of caudal vertebrae	18
Total number of vertebrae	49
Number of fused cervical vertebrae	none
Greatest width of articulating surface of atlas	101.9
Height of atlas – from internal anterodorsal margin of neural canal to bottom of anterior face of body	60.9
Length of lateral process of atlas – from margin of anterior articulating surface to farthest point at end of process	28.3
Greatest length of neural spine of atlas	41.1
Height of dorsal ridge of atlas in anterior view	22.8
Length of right dorsolateral spine of atlas	25.1
Length of lateral process of axis – from margin of posterior articulating surface to distal end of process	24.5
Number of cervical vertebrae with incomplete neural arches	2
Cervical vertebra on which left ventrolateral process reaches greatest development	5th
Vertebra on which first vertical perforating foramen appears	25th
First vertebra with greatly reduced metapophyses	25th
Last vertebra with distinct transverse processes	25th
Last vertebra with distinct neural process	25th
First vertebra with unfused epiphysis	25th
Last vertebra with unfused epiphysis	25th
First caudal vertebra with vertical neural spine	3rd
Length of neural spine of first thoracic – from anterodorsal margin of neural canal to tip of spine	36.5
Length of neural spine of second thoracic vertebra	46.5
Length of neural spine of tenth thoracic vertebra	65
Length of neural spine of last thoracic vertebra	69.4
Height of first thoracic vertebra – from internal anterodorsal margin of neural canal to bottom of anterior face of body	55.0
Greatest width of first thoracic vertebra – across lateral processes	89.2
Height of the first lumbar vertebra	57.5
Greatest width of the first lumbar vertebra	164.9
Length of 23d centrum, exclusive of epiphyses, along vertical midline	40.1
Number of vertebral ribs – left	12
Number of vertebral ribs – right	12
Number of two-headed ribs – left	6
Number of two-headed ribs – right	6
Number of floating ribs – left	1
Number of floating ribs – right	2
Number of sternal ribs – left	5
Number of sternal ribs – right	5
Greatest length of first left vertebral rib	123.6
Width of first left vertebral rib at apex of proximal curvature	19.7
Greatest length of longest left vertebral rib	141.4
Greatest width of manubrium	88.8
Length of manubrium along midline	84
Depth of anterior notch of manubrium	12
Length of foramen in manubrium	5
Number of chevron bones	7
Vertebra bearing first chevron bone	24th
Vertebra bearing last chevron bone	31st
Greatest length of first half of largest chevron bone	44.3
Greatest length of first half of last chevron bone	22.9
Height of scapula – from posterior margin of glenoid fossa to coracovertebral angle	125.1
Length of scapula – from posterior margin of glenoid fossa to glenovertebral angle	110.3
Greatest length of coracoid process – from anterior margin of glenoid fossa	21.5
Greatest width of coracoid process	11.6
Greatest width of metacromion process – from apex of ventral curvature to vertebral apex	54.5
Greatest length of humerus, measured on ventral side of flipper	63.9
Greatest width of humerus distally	39.5
Greatest length of radius	74
Greatest width of radius distally	38.2
Greatest length of ulna	65.9
Transverse breadth of proximal row of carpals	73
Greatest length of left pelvic rudiment	108.7

Measurement of the tympanoperiotic bones of the neotype.

Measurement	Neotype	
	Left	Right
Length of tympanic bulla, from anterior tip to posterior end of outer posterior prominence	33.7	34.3
Anterior tip to posterior end of inner prominence	32.8	33.2
Postero-ventral tip of outer posterior prominence to tip of sigmoid process	21.6	24.6
Postero-ventral tip of outer posterior prominence to tip of conical process	17.9	18.0
Width of tympanic bulla, at the level of the sigmoid process	20.7	21.3
Height of tympanic bulla, from tip of sigmoid process to ventral keel	22.6	25.0
Width across inner and outer posterior prominences	18.5	18.3
Greater depth of interprominental notch	5.3	4.7
Width of upper border of sigmoid process	–	5.0
Width of the posterior branch of lower tympanic aperture	2.0	1.2
The thicker side between outer and inner posterior prominences	8.6	10.5
Length of periotic, from tip of anterior process to posterior end of posterior process, measured on a straight line parallel with cerebral border	32.0	31.9
Thickness of superior process at the level of upper tympanic aperature	11.8	13.0
Width of periotic across cochlear portion and superior process, at the level of upper tympanic aperture	21.8	22.2
Least distance between the margins of the fundus of the internal auditory meatus and of the aperature of ductus endolymphaticus	2.3	2.4
Least distance between the margins of the fundus of the internal auditory meatus and of the aperture of aquaductus cochleae	4.9	4.2
Length of articular facet of the posterior process of periotic for the posterior process of tympanic bulla	18.3	15.9
Antero-posterior diameter of cochlear portion	21.3	19.0
Maximum depth of inner part of involvucrum	9.3	9.1